Facts About Dietary Supplements

Clinical Nutrition Service, Warren Grant Magnuson Clinical Center • Office of Dietary Supplements • National Institutes of Health

# Vitamin A and Carotenoids

*As a consumer, you need information you can trust to help you make thoughtful decisions about eating a healthful diet and using vitamin and mineral supplements. Registered dietitians at the Warren Grant Magnuson Clinical Center, the clinical research hospital at the National Institutes of Health (NIH) in Bethesda, MD, developed this series of Fact Sheets in conjunction with the Office of Dietary Supplements in the Office of the Director of NIH to provide responsible information about the role of vitamins and minerals in health and disease and to help guide your decisions on the use of vitamin and mineral supplements. Each fact sheet in this series received extensive scientific review by recognized experts from the academic and research communities. The information is not intended to be a substitute for professional medical advice. It is important that you seek the advice of a physician about any medical condition or symptom. It is also important to seek the advice of a physician, registered dietitian, pharmacist, or other qualified health care professional about the appropriateness of taking dietary supplements and their potential interactions with medications.*

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**Vitamin A: What is it?**

Vitamin A is a family of fat-soluble vitamins. Retinol is one of the most active, or usable, forms of vitamin A, and is found in animal foods such as liver and eggs. Retinol is often called preformed vitamin A. It can be converted to retinal and retinoic acid, other active forms of the vitamin A family (1-4). Some plant foods contain darkly colored pigments called provitamin A carotenoids that your body can convert to vitamin A. Approximately 26% and 34% of vitamin A consumed by men and women is provided by these provitamin A carotenoids (1). Beta-carotene is a provitamin A carotenoid that is more efficiently converted to retinol than other carotenoids (1-4). For example, alpha-carotene is also converted to vitamin A, but only half as efficiently as beta-carotene (1). Lycopene, lutein, and zeaxanthin are other carotenoids commonly found in food. Your body cannot convert them to vitamin A, but they help maintain good health in other ways.

Vitamin A plays an important role in vision, bone growth, reproduction, cell division and cell differentiation, which is the process by which a cell decides what it is going to become (1, 5-8). It also maintains the surface linings of your eyes and your respiratory, urinary, and intestinal tracts (9). When those linings break down, bacteria can enter your body and cause infection (9). Vitamin A also helps your body regulate its immune system (2, 5, 10). The immune system helps prevent or fight off infections by making white blood cells that destroy harmful bacteria and viruses. Vitamin A may help lymphocytes, a type of white blood cell that fights infections, function more effectively. Vitamin A also may help prevent bacteria and viruses from entering your body by maintaining the integrity of skin and mucous membranes (11-13).

Some carotenoids, in addition to serving as a source of vitamin A, have been shown to function as antioxidants in laboratory tests. However, this role has not been consistently demonstrated in humans (1). Antioxidants protect cells from free radicals, which are potentially damaging by-

products of your body's metabolism that may contribute to the development of some chronic diseases (3, 14-16).

**What foods provide vitamin A?**
Whole eggs, whole milk, and liver are among the few foods that naturally contain vitamin A. Most fat free milk and dried nonfat milk solids sold in the US are fortified with vitamin A to replace the vitamin A lost when the fat is removed (17). Fortified foods such as fortified breakfast cereals also provide vitamin A. The tables of selected food sources of vitamin A list a variety of animal sources of vitamin A and plant sources of provitamin A carotenoids (18).

It is important for you to regularly eat foods that provide vitamin A or beta-carotene even though your body can store vitamin A in the liver (2). Stored vitamin A will help meet your needs when intake of provitamin A carotenoids or preformed vitamin A is low (19.20).

**What is the Recommended Dietary Allowance for vitamin A for children and adults?**
Dietary Reference Intakes are reference values used for planning and assessing diets for healthy people. The Recommended Dietary Allowance, one of the DRIs, recommends the average daily dietary intake level that is sufficient to meet the nutrient requirements of nearly all (97-98%) healthy individuals in each age and gender group (1). RDAs for vitamin A are listed as retinal activity equivalents (RAE) to account for the different activities of retinol and provitamin A carotenoids (1 RAE = 1 microgram retinol). RDAs are also listed in International Units (IU) because food and some supplement labels list vitamin A content in International Units (1 IU vitamin A = 0.3 mcg retinol or 1 mcg RAE)). The 2001 RDAs for adults and children (21) in micrograms (mcg) RAE and IUs are:

| Age | Children | Men | Women | Pregnancy | Lactation |
|---|---|---|---|---|---|
| Ages 1-3 | 300 mcg or 1000 IU* | | | | |
| Ages 4-8 | 400 mcg or 1333 IU | | | | |
| Ages 9-13 | 600 mcg or 2000 IU | | | | |
| Ages 14-18 | | 900 mcg (3000 IU) | 700 mcg (2330 IU) | 750 mcg (2,500 IU) | 1,200 mcg (4,000 IU) |
| Ages 19+ | | 900 mcg (3000 IU) | 800 RE or 4000 IU | 770 mcg (2565 IU) | 1,300 mcg (4335 IU) |

*Food labels list vitamin A in International Units (IU).

There is insufficient information to establish a RDA for vitamin A for infants. An adequate intake (AI) has been established that is based on the amount of vitamin A consumed by healthy infants who are fed breast milk (1). The AI for vitamin A for infants ages 0 to 6 months is 400 micrograms per day (1,330 IU). The AI for vitamin A for infants ages 7 to 12 months is 500 micrograms per day (1,665 IU).

Results of two national surveys, the third National Health and Nutrition Examination Survey (NHANES III 1988-91) (1, 21) and the Continuing Survey of Food Intakes by Individuals (CSFII 1994) (1, 22) suggested that the dietary intake of some Americans does not meet recommended levels for vitamin A. These surveys highlight the importance of encouraging all Americans to include dietary sources of vitamin A in their daily diets.

There is no separate RDA for beta-carotene or other provitamin A carotenoids. The Institute of Medicine report suggests that consuming 3 to 6 mg of beta-carotene daily will maintain plasma beta-carotene blood levels in the range associated with a lower risk of chronic diseases (1). A diet that provides five or more servings of fruits and vegetables per day and includes some dark green and leafy vegetables and deep yellow or orange fruits will provide recommended amounts of beta-carotene.

**When can vitamin A deficiency occur?**

Vitamin A deficiency rarely occurs in the United States, but it is still a major public health problem in the developing world. From 3 to 10 million children develop xeropthalmia, damage to the cornea of the eye, and 250,000 to 500,000 go blind each year from a deficiency of vitamin A (1). Most of these children live in developing countries. Night blindness is one of the first signs of vitamin A deficiency. In ancient Egypt it was known that night blindness could be cured by eating liver, which was later found to be a rich source of vitamin A (2). Vitamin A deficiency contributes to blindness by making the eye very dry and promoting damage to the retina of the eye (23). Other signs of vitamin A deficiency are dry skin, dry hair, broken fingernails, and decreased resistance to infections. In countries where immunization programs are not widespread and vitamin A deficiency is common, millions of children die each year from complications of infectious diseases such as measles. (9). When there is not enough vitamin A, cells lining the lung lose their ability to remove disease-causing microorganisms. This may contribute to the pneumonia associated with vitamin A deficiency (2,10,11).

There is increased interest in subclinical forms of vitamin A deficiency, described as low storage levels of vitamin A that do not cause overt deficiency symptoms. This mild degree of vitamin A deficiency may increase children's risk of developing respiratory and diarrheal infections, decrease growth rate, slow bone development, and decrease likelihood of survival from serious illness (8, 24, 25). Children living in the United States who are considered to be at increased risk for subclinical vitamin A deficiency include:

- toddlers and preschool age children,
- children living at or below the poverty level,
- children with inadequate health care or immunizations,
- children living in areas with known nutritional deficiencies,
- recent immigrants or refugees from developing countries with high incidence of vitamin A deficiency or measles, and
- children with diseases of the pancreas, liver, intestines, or with inadequate fat digestion/absorption (9).

Vitamin A deficiency can also occur when vitamin A is lost through diarrhea, depletion of liver stores of vitamin A, and through an overall inadequate intake, as is often seen with protein-calorie malnutrition.

Low plasma retinol concentration, which is considered a good indicator of inadequate vitamin A nutritional status, can also result from an inadequate intake of protein, calories, and zinc. These nutrients are needed to make Retinol Binding Protein (RBP), which is essential for mobilizing vitamin A from your liver and transporting vitamin A to your general circulation (1).

Iron deficiency can also limit the metabolism of vitamin A, and iron supplements provided to iron deficient individuals may improve vitamin A nutriture as much as iron status (1).

Excess alcohol intake depletes vitamin A from your body and is associated with reduced vitamin A intake (1). It is very important for anyone who consumes excessive amounts of alcohol to include good sources of vitamin A in his or her diet. Vitamin A supplementation may not be recommended for individuals who abuse alcohol because alcohol may increase liver toxicity associated with excess intakes of vitamin A (1,26 ). A medical doctor would need to evaluate this situation and determine the need for vitamin A supplementation.

**Who may need extra vitamin A to prevent a deficiency?**

As a result of the adverse health effects of vitamin A deficiency in children, the World Health Organization (WHO) and the United Nations International Children's Emergency Fund (UNICEF) issued joint statements about vitamin A and children's health. Both agencies recommend vitamin A administration for all children diagnosed with measles in communities where vitamin A deficiency is a serious problem and where death from measles is greater than 1%. In 1994, the American Academy of Pediatrics recommended vitamin A supplementation for two subgroups of children likely to be at high risk for subclinical vitamin A deficiency. These subgroups were children 6-24 months of age who had been hospitalized with measles and hospitalized children older than 6 months (27).

Fat malabsorption can promote diarrhea and prevent normal absorption of vitamin A. This is most often seen with cystic fibrosis, sprue, pancreatic disorders, and after stomach surgery. Healthy adults usually have a one-year reserve of vitamin A stored in their livers and should not be at risk of deficiency during periods of temporary or short term fat malabsorption. Long-term problems absorbing fat, however, can result in deficiency, and in these instances physicians may advise vitamin A supplementation (9). Children may only have enough stores of vitamin A to last several weeks. Physicians treating children with fat malabsorption may recommend vitamin A supplementation (9).

Vegetarians who do not consume eggs and dairy foods need greater amounts of provitamin A carotenoids to meet their need for vitamin A (1). It is important for vegetarians to include a minimum of five servings of fruits and vegetables daily and to regularly choose dark green leafy vegetables and orange and yellow fruits to consume recommended amounts of vitamin A.

**What is the association between vitamin A, beta carotene and cancer?**

Surveys suggest an association between diets rich in beta-carotene and vitamin A and a lower risk of many types of cancer (2, 28). There is evidence that a higher intake of green and yellow vegetables or food sources of beta-carotene and/or vitamin A may decrease the risk of lung cancer (29). However, a number of studies that tested the role of beta-carotene supplements in cancer prevention did not find it to be protective (30). In a study of 29,000 men, incidence of lung cancer was greater in the group of smokers who took a daily supplement of beta-carotene (31). The Carotene and Retinol Efficacy Trial, a lung cancer chemoprevention trial that provided randomized subjects with supplements of beta-carotene and vitamin A, was stopped after researchers discovered that subjects receiving beta-carotene had a 46% higher risk of dying from lung cancer (32). The IOM states that "beta-carotene supplements are not advisable for the general population," although they also state that this advice "does not pertain to the possible use of supplemental beta-carotene as a provitamin A source for the prevention of vitamin A deficiency in populations with inadequate vitamin A nutriture" (1).

**What is the health risk of too much vitamin A?**

Hypervitaminosis A refers to high storage levels of vitamin A in the body that can lead to toxic symptoms. There are three major adverse effects of hypervitaminosis A: birth defects, liver abnormalities, and reduced bone mineral density that may result in osteoporosis (1). When toxic symptoms arise suddenly, which can happen after consuming very large amounts of preformed vitamin A over a short period of time, signs of toxicity include nausea and vomiting, headache, dizziness, blurred vision, and muscular uncoordination (1, 7-9, 33, 34).

Although hypervitaminosis A can occur when very large amounts of liver are regularly consumed, most cases of vitamin A toxicity result from an excess intake of vitamin A in supplements. The Institute of Medicine has established tolerable upper levels (UL) of intake for vitamin A from supplements (1) to help prevent the risk of toxicity. The risk of adverse health effects increases at intakes greater than the UL.

**Table of Upper Limits (UL) in micrograms (mcg) and International Units (IU) for Retinal Activity Equivalents**

| Age | Children | Men | Women | Pregnancy | Lactation |
|---|---|---|---|---|---|
| Ages 0-12 months | 600 mcg (2,000 IU) | | | | |
| Ages 1-3 | 600 mcg (2,000 IU) | | | | |
| Ages 4-8 | 900 mcg (3000 IU) | | | | |
| Ages 9-13 | 1,700 mcg (5665 IU) | | | | |
| Ages 14-18 | | 2,800 mcg (9335 IU) | 2,800 mcg (9335 IU)) | 2,800 mcg (9335 IU)) | 2,800 mcg (9335 IU) |
| Ages 19+ | | 3,000 mcg (10,000 IU) | 3,000 mcg (10,000 IU) | 3,000 mcg (10,000 IU) | 3,000 mcg (10,000 IU) |

Retinoids are compounds that are chemically similar to vitamin A. Over the past 15 years, synthetic retinoids have been prescribed for acne, psoriasis, and other skin disorders (35). Isotretinoin ("Roaccutane" or" Accutane") is considered an effective anti-acne therapy. At very high doses, however, it can be toxic, which is why this medication is usually saved for the most severe forms of acne (36-38). The most serious consequence of this medication is birth defects. It is extremely important for sexually active females who may become pregnant and who take these medications to use an effective method of birth control. Women of childbearing age who

take these medications are advised to undergo monthly pregnancy tests to make sure they are not pregnant.

**What is the health risk of too many carotenoids?**

Nutrient toxicity traditionally refers to adverse health effects from a high intake of a particular vitamin or mineral. For example, large amounts of active, or preformed, vitamin A (naturally found in animal foods such as liver but also available in dietary supplements) can cause birth defects.

Provitamin A carotenoids such as beta-carotene are generally considered safe because they are not traditionally associated with specific adverse health effects. The conversion of provitamin A carotenoids to vitamin A decreases when body stores are full, which naturally limits further increases in storage levels. A high intake of provitamin A carotenoids can turn the skin yellow, but this is not considered dangerous to health.

Recent clinical trials that associated beta-carotene supplements with a greater incidence of lung cancer and death in current smokers raised concern about the safety of beta-carotene supplements. However, conflicting studies make it difficult to interpret the health risk. For example, the Physicians' Health Study compared the effects of taking 50 mg beta-carotene every other day to a placebo (sugar pill) in over 22,000 male physicians and found no adverse health effects (39). Also, a trial that tested the ability of four different nutrient combinations to inhibit the development of esophageal and gastric cancers in 30,000 men and women in China suggested that after 5 years those participants who took a combination of beta-carotene, selenium and vitamin E had a 13% reduction in cancer deaths (40). One point to consider is that there may be a relationship between alcohol and beta-carotene because "only those men who consumed more than 11 g per day of alcohol (approximately one drink per day) showed an adverse response to B-carotene supplementation" in the lung cancer trial (1).

The Institute of Medicine did not set a Tolerable Upper Intake Level (UL) for carotene or carotenoids. Instead, they concluded that beta-carotene supplements are not advisable for the general population. As stated earlier, however, they may be appropriate as a provitamin A source or for the prevention of vitamin A deficiency in specific populations (1).

**Selected Food Sources of vitamin A**

As the 2000 Dietary Guidelines for Americans state, "Different foods contain different nutrients. No single food can supply all the nutrients in the amounts you need" (41). The following tables list a variety of dietary sources of vitamin A and provitamin A carotenoids. As the tables indicate, liver, eggs and whole milk are good animal sources of vitamin A. Many orange fruits and green vegetables are good sources of provitamin A carotenoids. Including these foods in your daily diet will help you meet your daily need for vitamin A. In addition, food manufacturers fortify a wide range of products with vitamin A. Breakfast cereals, pastries, breads, crack-

ers, cereal grain bars and other foods may be fortified with 10% to 15% of the DV for vitamin A. If you want more information about building a healthful diet, refer to the Dietary Guidelines for Americans and the Food Guide Pyramid.

**Table of Selected Animal Sources of Vitamin A (18)**

| *Food* | *IU/International Unit* | *% DV** |
|---|---|---|
| Liver, beef, cooked, 3 oz | 30,325 | 610 |
| Liver, chicken, cooked, 3 oz | 13,920 | 280 |
| Egg substitute, fortified, 1/4 c | 1355 | 25 |
| Fat free milk, fortified w/vitamin A, 1 c | 500 | 10 |
| Cheese pizza 1/8 of a 12-inch diameter | 380 | 8 |
| Milk, whole 1 cup | 305 | 6 |
| Cheddar cheese, 1 oz | 300 | 6 |
| Whole egg, 1 medium | 280 | 6 |
| Swiss cheese, 1 oz | 240 | 4 |
| Yogurt, fruit flavored, lowfat, 1 c | 120 | 2 |

* DV = Daily Value. DVs are reference numbers based on the Recommended Dietary Allowance (RDA). They were developed to help consumers determine if a food contains a lot or a little of a specific nutrient. The DV for vitamin A is 5,000 IU (1,500 micrograms retinol). The percent DV (%DV) listed on the nutrition facts panel of food labels tells adults what percentage of the DV is provided in one serving. Percent DVs are based on a 2,000 calorie diet. Your Daily Values may be higher or lower depending on your calorie needs. Foods that provide lower percentages of the DV also contribute to a healthful diet.

**Table of Selected Plant Sources of Vitamin A (from beta-carotene) (18)**

Plant sources such as beta carotene are not as well absorbed as animal sources of vitamin A.

| *Food* | *IU/International Units* | *% DV** |
|---|---|---|
| Carrot, 1 raw, 7 1/2 inches | 20,250 | 410 |
| Carrots, boiled, 1/2-cup slices | 19,150 | 380 |
| Carrot juice, canned, 1/2 cup | 12,915 | 260 |
| Mango, raw, 1 fruit | 8,050 | 160 |
| Sweet potatoes, 1/2 cup Junior mashed | 7,430 | 150 |
| Spinach, boiled, 1/2 cup | 7,370 | 150 |
| Cantaloupe, raw, 1 cup cubes | 5,160 | 100 |
| Kale, boiled, 1/2 cup | 4,810 | 100 |
| Vegetable soup, prepared with equal volume water, 1 cup | 3,005 | 60 |
| Pepper, sweet, red, raw, 1/2 cup sliced | 2,620 | 50 |
| Apricots, without skin, canned in water, 1/2 cup halves | 2,055 | 40 |
| Spinach, raw, 1 cup | 2,015 | 40 |

**Table of Selected Plant Sources of Vitamin A (from beta-carotene) (18)**

Plant sources such as beta carotene are not as well absorbed as animal sources of vitamin A.

| *Food* | *IU/International Unit* | *% DV** |
|---|---|---|
| Broccoli, frozen, chopped, boiled,1/2 cup | 1,740 | 35 |
| Apricot nectar, canned, 1/2 cup | 1,650 | 30 |
| Oatmeal, instant, fortified, low sodium, dry, 1 packet | 1,050 | 20 |
| Tomato juice, canned, 6 oz | 1,010 | 20 |
| Ready-to-eat cereal, fortified, 1 oz(15% fortification) | 750 | 15 |
| Peaches, canned, water pack, 1/2c halves or slices | 650 | 15 |
| Peach, raw, 1 medium | 525 | 10 |
| Papaya, raw, 1 small | 430 | 10 |
| Orange, raw, 1 large | 375 | 8 |
| Asparagus, boiled, 4 spears | 325 | 6 |
| Tomato, red, ripe, raw, 1/2" thick slice | 170 | 2 |

* DV = Daily Value. DVs are reference numbers based on the Recommended Dietary Allowance (RDA). They were developed to help consumers determine if a food contains a lot or a little of a specific nutrient. The DV for vitamin A is 5,000 IU (1,500 micrograms retinol). The percent DV (%DV) listed on the nutrition facts panel of food labels tells adults what percentage of the DV is provided in one serving. Percent DVs are based on a 2,000 calorie diet. Your Daily Values may be higher or lower depending on your calorie needs. Foods that provide lower percentages of the DV also contribute to a healthful diet.

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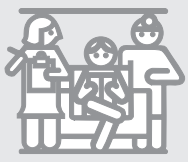



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